

CLAIMS

[1] A compressor for compressing air applied to a jet engine,
the compressor characterized by comprising:

a titanium compressor case composed of a titanium alloy;

5 a compressor rotor arranged inside the compressor case, the
compressor rotor including plural titanium rotor blades at even
intervals and being rotatable around a case axial center of the
titanium compressor case,

wherein, instead of having an abradable coating formed on
10 an internal surface of the titanium compressor case,
each of the titanium rotor blades includes;

a rotor blade main body composed of a titanium alloy;

a deposition layer formed at a tip end portion of the rotor
blade main body, the deposition layer being formed by using a first
15 electrode composed of a first molded body molded from a powder
of a cobalt-chromium alloy or a nickel alloy, or the first molded
body processed with a heat treatment, generating pulsing electric
discharges between the tip end portion of the rotor blade main
body and the first electrode in an electrically insulating liquid
20 or gas, and welding a material of the first electrode or a reacting
substance of the material of the first electrode on the tip end
portion of the blade main body by means of energy of the electric
discharges; and

an abrasive coating having abrasiveness formed at a blade
25 pressure side of the deposition layer, the abrasive coating being
formed by using a second electrode composed of a second molded
body molded from a mixed powder including a powder of a metal and
a powder of a ceramic or the second electrode processed with a
heat treatment, generating pulsing electric discharges between
30 the blade pressure side of the deposition layer and the second
electrode in an electrically insulating liquid or gas, and welding
a material of the second electrode or a reacting substance of the
material of the second electrode on the blade pressure side of
the deposition layer by means of energy of the electric discharges.

35 [2] A compressor for compressing air applied to a jet engine,
the compressor characterized by comprising:

a titanium compressor case composed of a titanium alloy;

a compressor rotor arranged inside the compressor case, the compressor rotor including plural titanium rotor blades at even intervals and being rotatable around a case axial center of the titanium compressor case,

5 wherein, instead of having an abradable coating formed on an internal surface of the titanium compressor case,

each of the titanium rotor blades includes;

a rotor blade main body composed of a titanium alloy;

10 a deposition layer formed at a tip end portion of the rotor blade main body, the deposition layer being formed by using a first electrode composed of a first molded body molded from a powder of a cobalt-chromium alloy or a nickel alloy, or the first molded body processed with a heat treatment, generating pulsing electric discharges between the tip end portion of the rotor blade main body and the first electrode in an electrically insulating liquid or gas, and welding a material of the first electrode or a reacting substance of the material of the first electrode on the tip end portion of the blade main body by means of energy of the electric discharges; and

20 an abrasive coating having abrasiveness formed at a blade pressure side of the deposition layer, the abrasive coating being formed by using a second electrode composed of a solid body of Si, a second molded body molded from a powder of Si, or the second molded body processed with a heat treatment, generating pulsing electric discharges between the blade pressure side of the deposition layer and the second electrode in an electrically insulating oil, and welding a material of the second electrode or a reacting substance of the material of the second electrode on the blade pressure side of the deposition layer by means of 25 energy of the electric discharges.

30 [3] The compressor recited in claim 1 or claim 2, characterized in that fused portions are respectively generated at a boundary between the deposition layer and the tip end portion of the rotor blade main body and a boundary between the abrasive coating and the deposition layer, in each of the fused portions a composition ratio grading in its thickness direction, the fused portions being constituted so as to be 3 μm or more and 20 μm or less in thickness.

[4] A compressor for compressing air applied to a jet engine, the compressor characterized by comprising:

a titanium compressor case composed of a titanium alloy;

a compressor rotor arranged inside the compressor case, the

5 compressor rotor including plural titanium rotor blades at even intervals and being rotatable around a case axial center of the titanium compressor case,

wherein, instead of having an abradable coating formed on an internal surface of the titanium compressor case,

10 each of the titanium rotor blades includes;

a rotor blade main body composed of a titanium alloy; and

an abrasive coating having abrasiveness formed at a portion

ranging from a blade pressure side to a leading end side of the rotor blade main body, the abrasive coating being formed by using

15 an electrode composed of a molded body molded from a mixed powder including a powder of a metal and a powder of a ceramic or a powder of an electrically conductive ceramic, or the electrode processed with a heat treatment, generating pulsing electric discharges between the portion ranging from the blade pressure side to the

20 leading end side of the rotor blade main body and the electrode in an electrically insulating liquid or gas, and welding a material of the electrode or a reacting substance of the material of the electrode on the portion ranging from the blade pressure side to the leading end side of the rotor blade main body by means of energy

25 of the electric discharges.

[5] A compressor for compressing air applied to a jet engine, the compressor characterized by comprising:

a titanium compressor case composed of a titanium alloy;

a compressor rotor arranged inside the compressor case, the

30 compressor rotor including plural titanium rotor blades at even intervals and being rotatable around a case axial center of the titanium compressor case,

wherein, instead of having an abradable coating formed on an internal surface of the titanium compressor case,

35 each of the titanium rotor blades includes;

a rotor blade main body composed of a titanium alloy; and

an abrasive coating having abrasiveness formed at a portion

ranging from a blade pressure side to a leading end side of the rotor blade main body, the abrasive coating being formed by using an electrode composed of a solid body of Si, a molded body molded from a powder of Si, or the molded body processed with a heat treatment,
5 generating pulsing electric discharges between the portion ranging from the blade pressure side to the leading end side of the rotor blade main body and the electrode in an electrically insulating oil, and welding a material of the electrode or a reacting substance of the material of the electrode on the portion ranging from the
10 blade pressure side to the leading end side of the rotor blade main body by means of energy of the electric discharges.

[6] The compressor recited in claim 4 or claim 5, characterized in that a fused portion is generated at a boundary between the abrasive coating and the deposition layer, in the fused portion
15 a composition ratio grades in its thickness direction, the fused portion being constituted so as to be 3 μm or more and 20 μm or less in thickness.

[7] The compressor recited in claim 1 or claim 4, characterized in that the ceramic is any one material or any two or more mixed
20 materials from cBN, TiC, TiN, TiAlN, TiB₂, WC, SiC, Si₃N₄, Cr₃C₂, Al₂O₃, ZrO₂-Y, ZrC, VC and B₄C.

[8] A titanium rotor blade applied to a compressor in a jet engine, the titanium rotor blade characterized by comprising:

a rotor blade main body composed of a titanium alloy;
25 a deposition layer formed at a tip end portion of the rotor blade main body, the deposition layer being formed by using a first electrode composed of a first molded body molded from a powder of a cobalt-chromium alloy or a nickel alloy, or the first molded body processed with a heat treatment, generating pulsing electric
30 discharges between the tip end portion of the rotor blade main body and the first electrode in an electrically insulating liquid or gas, and welding a material of the first electrode or a reacting substance of the material of the first electrode on the tip end portion of the blade main body by means of energy of the electric
35 discharges; and

an abrasive coating having abrasiveness formed at a blade pressure side of the deposition layer, the abrasive coating being

formed by using a second electrode composed of a second molded body molded from a mixed powder including a powder of a metal and a powder of a ceramic or the second electrode processed with a heat treatment, generating pulsing electric discharges between the blade pressure side of the deposition layer and the second electrode in an electrically insulating liquid or gas, and welding a material of the second electrode or a reacting substance of the material of the second electrode on the blade pressure side of the deposition layer by means of energy of the electric discharges.

5 [9] A titanium rotor blade applied to a compressor in a jet engine, the titanium rotor blade characterized by comprising:

- a rotor blade main body composed of a titanium alloy;
- a deposition layer formed at a tip end portion of the rotor blade main body, the deposition layer being formed by using a first electrode composed of a first molded body molded from a powder of a cobalt-chromium alloy or a nickel alloy, or the first molded body processed with a heat treatment, generating pulsing electric discharges between the tip end portion of the rotor blade main body and the first electrode in an electrically insulating liquid or gas, and welding a material of the first electrode or a reacting substance of the material of the first electrode on the tip end portion of the blade main body by means of energy of the electric discharges; and

10 an abrasive coating having abrasiveness formed at a blade pressure side of the deposition layer, the abrasive coating being formed by using a second electrode composed of a solid body of Si, a second molded body molded from a powder of Si, or the second molded body processed with a heat treatment, generating pulsing electric discharges between the blade pressure side of the deposition layer and the second electrode in an electrically insulating oil, and welding a material of the second electrode or a reacting substance of the material of the second electrode on the blade pressure side of the deposition layer by means of energy of the electric discharges.

15 [10] The titanium rotor blade recited in claim 8 or claim 9, characterized in that fused portions are respectively generated at a boundary between the deposition layer and the tip end portion

of the rotor blade main body and a boundary between the abrasive coating and the deposition layer, in each of the fused portions a composition ratio grading in its thickness direction, the fused portions being constituted so as to be 3 μm or more and 20 μm or 5 less in thickness.

[11] A titanium rotor blade applied to a compressor in a jet engine, the titanium rotor blade characterized by comprising:

a rotor blade main body composed of a titanium alloy; and
an abrasive coating having abrasiveness formed at a portion 10 ranging from a blade pressure side to a leading end side of the rotor blade main body, the abrasive coating being formed by using an electrode composed of a molded body molded from a mixed powder including a powder of a metal and a powder of a ceramic or a powder of an electrically conductive ceramic, or the electrode processed 15 with a heat treatment, generating pulsing electric discharges between the portion ranging from the blade pressure side to the leading end side of the rotor blade main body and the electrode in an electrically insulating liquid or gas, and welding a material of the electrode or a reacting substance of the material of the 20 electrode on the portion ranging from the blade pressure side to the leading end side of the rotor blade main body by means of energy of the electric discharges.

[12] A titanium rotor blade applied to a compressor in a jet engine, the titanium rotor blade characterized by comprising:

a rotor blade main body composed of a titanium alloy; and
an abrasive coating having abrasiveness formed at a portion 25 ranging from a blade pressure side to a leading end side of the rotor blade main body, the abrasive coating being formed by using an electrode composed of a solid body of Si, a molded body molded from a powder of Si, or the molded body processed with a heat treatment, 30 generating pulsing electric discharges between the portion ranging from the blade pressure side to the leading end side of the rotor blade main body and the electrode in an electrically insulating oil, and welding a material of the electrode or a reacting substance 35 of the material of the electrode on the portion ranging from the blade pressure side to the leading end side of the rotor blade main body by means of energy of the electric discharges.

[13] The titanium rotor blade recited in claim 11 or claim 12, characterized in that a fused portion is generated at a boundary between the abrasive coating and the deposition layer, in the fused portion a composition ratio grades in its thickness direction, 5 the fused portion being constituted so as to be 3 μm or more and 20 μm or less in thickness.

[14] The titanium rotor blade recited in claim 8 or claim 11, characterized in that the ceramic is any one material or any two or more mixed materials from cBN, TiC, TiN, TiAlN, TiB₂, WC, SiC, 10 Si₃N₄, Cr₃C₂, Al₂O₃, ZrO₂-Y, ZrC, VC and B₄C.

[15] A compressor characterized by comprising the titanium rotor blade recited in any claim from claim 8 to claim 14.

[16] A jet engine characterized by comprising the compressor recited in any claim of from claim 1 to claim 7 and claim 15.

15 [17] A production method of a titanium rotor blade for producing the titanium rotor blade from a rotor blade main body composed of a titanium alloy, the production method of the titanium rotor blade characterized by producing the titanium rotor blade from the rotor blade main body, by:

20 forming a deposition layer at a tip end portion of the rotor blade main body by using a first electrode composed of a first molded body molded from a powder of a cobalt-chromium alloy or a nickel alloy, or the first molded body processed with a heat treatment, generating pulsing electric discharges between the tip 25 end portion of the rotor blade main body and the first electrode in an electrically insulating liquid or gas, and welding a material of the first electrode or a reacting substance of the material of the first electrode on the tip end portion of the blade main body by means of energy of the electric discharges; and

30 forming an abrasive coating having abrasiveness at a blade pressure side of the deposition layer by using a second electrode composed of a second molded body molded from a mixed powder including a powder of a metal and a powder of a ceramic or the second electrode processed with a heat treatment, generating pulsing electric 35 discharges between the blade pressure side of the deposition layer and the second electrode in an electrically insulating liquid or gas, and welding a material of the second electrode or a reacting

substance of the material of the second electrode on the blade pressure side of the deposition layer by means of energy of the electric discharges.

[18] A production method of a titanium rotor blade for producing
5 the titanium rotor blade from a rotor blade main body composed
of a titanium alloy, the production method of the titanium rotor
blade characterized by producing the titanium rotor blade from
the rotor blade main body, by:

forming a deposition layer at a tip end portion of the rotor
10 blade main body by using a first electrode composed of a first
molded body molded from a powder of a cobalt-chromium alloy or
a nickel alloy, or the first molded body processed with a heat
treatment, generating pulsing electric discharges between the tip
end portion of the rotor blade main body and the first electrode
15 in an electrically insulating liquid or gas, and welding a material
of the first electrode or a reacting substance of the material
of the first electrode on the tip end portion of the blade main
body by means of energy of the electric discharges; and

forming an abrasive coating having abrasiveness at a blade
20 pressure side of the deposition layer by using a second electrode
composed of a solid body of Si, a second molded body molded from
a powder of Si, or the second molded body processed with a heat
treatment, generating pulsing electric discharges between the
blade pressure side of the deposition layer and the second electrode
25 in an electrically insulating oil, and welding a material of the
second electrode or a reacting substance of the material of the
second electrode on the blade pressure side of the deposition layer
by means of energy of the electric discharges.

[19] A production method of a titanium rotor blade for producing
30 the titanium rotor blade from a rotor blade main body composed
of a titanium alloy, the production method of the titanium rotor
blade characterized by producing the titanium rotor blade from
the rotor blade main body, by:

forming an abrasive coating having abrasiveness at a portion
35 ranging from a blade pressure side to a leading end side of the
rotor blade main body by using an electrode composed of a molded
body molded from a mixed powder including a powder of a metal and

a powder of a ceramic or a powder of an electrically conductive ceramic, or the electrode processed with a heat treatment, generating pulsing electric discharges between the portion ranging from the blade pressure side to the leading end side of the rotor

5 blade main body and the electrode in an electrically insulating liquid or gas, and welding a material of the electrode or a reacting substance of the material of the electrode on the portion ranging from the blade pressure side to the leading end side of the rotor blade main body by means of energy of the electric discharges.

10 [20] A production method of a titanium rotor blade for producing the titanium rotor blade from a rotor blade main body composed of a titanium alloy, the production method of the titanium rotor blade characterized by producing the titanium rotor blade from the rotor blade main body, by:

15 forming an abrasive coating having abrasiveness at a portion ranging from a blade pressure side to a leading end side of the rotor blade main body by using an electrode composed of a solid body of Si, a molded body molded from a powder of Si, or the molded body processed with a heat treatment, generating pulsing electric
20 discharges between the portion ranging from the blade pressure side to the leading end side of the rotor blade main body and the electrode in an electrically insulating oil, and welding a material of the electrode or a reacting substance of the material of the electrode on the portion ranging from the blade pressure side to
25 the leading end side of the rotor blade main body by means of energy of the electric discharges.

[21] The production method of the titanium rotor blade recited in any claim from claim 17 to claim 20, characterized in that an electric discharge condition at a time of generating the pulsing electric discharges is that a peak current is 30A or less and a pulse width is 200 μ s or less.

[22] The production method of the titanium rotor blade recited in claim 17 or claim 19, characterized in that the ceramic is any one material or any two or more mixed materials from cBN, TiC,
35 TiN, TiAlN, TiB₂, WC, SiC, Si₃N₄, Cr₃C₂, Al₂O₃, ZrO₂-Y, ZrC, VC and B₄C.

[23] A titanium rotor blade characterized by being produced by

the production method of the titanium rotor blade recited in any claim from claim 17 to claim 22.